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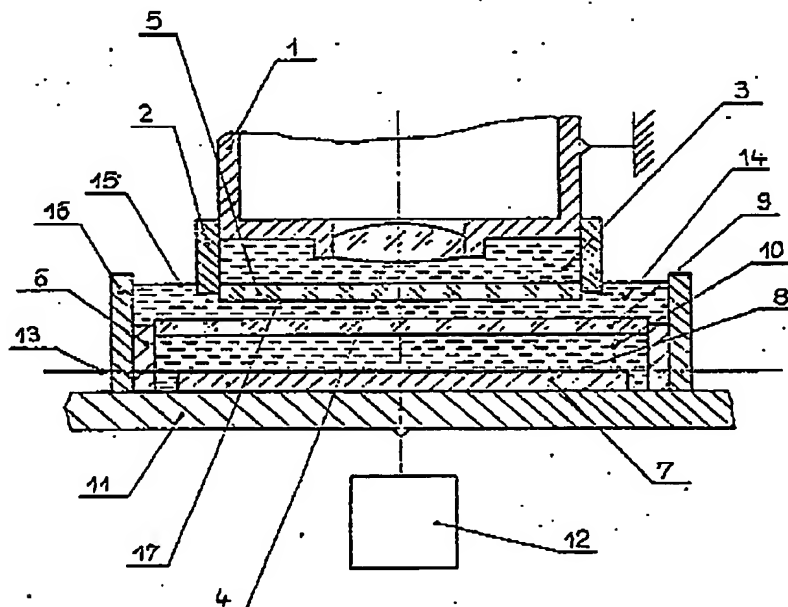
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(54) Apparatus for the photo-lithographic transfer of structures

(57) An apparatus for the photo-lithographic transfer of structures by means of a projection objective 1 (projection lens) is described. It is used for the production of semiconductor structures in a photo-sensitive layer 8 on a semiconductor disc 7 (wafer) using planar technology. The object of the invention is to increase the accuracy with a higher productivity of structure transfer, by providing an apparatus that, when using immersion liquid, avoids turbulence and keeps possible contamination outside the Depth-Of-Focus of the projection lens 1. The invention comprises two chambers 2,6 filled with an immersion liquid 3,10, one of which 2 is associated with the projection lens 1 and the second 10 is associated with the substrate 7. The highest resolution is achieved when immersion liquid 14 is also introduced between the optically transparent media 5,9 used to seal the chambers 2,10.



Figur 1

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Title of the Invention

Apparatus for the photo-lithographic transfer of structures

Field of Use of the Invention

The invention relates to an apparatus for the photo-lithographic transfer of structures by means of a projection objective (projection lens) to produce an exposure pattern in a photo-sensitive layer of a substrate. It is especially useful for the production of micro-structures in a photo-sensitive layer of a semiconductor disc (wafer) in the manufacture of semiconductor structures using planar technology.

Characteristics of known technical solutions (prior art)

The published European application EP 0 023 231 describes a method and an apparatus for copying a pattern onto a semiconductor wafer which uses, between a projection lens and a semiconductor plate, a liquid whose refractive index corresponds to that of the coating (resist) on the semiconductor wafer. Additionally, the liquid is constantly replaced and brought to the predetermined temperature and/or filtered. This apparatus allows the numerical aperture to be increased without increasing the incidence angles. This principle, also known in the field of microscopy (compare: Brockhaus, "ABC der Optik" (ABC of Optics) Brockhaus Publishing Leipzig, 1961 p. 565 ff.), proves disadvantageous when applied in the field of micro-lithography.

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In the disclosed method, the volume of liquid is considerable. One of the disadvantages is the turbulences produced in the liquid between the projection lens and the semiconductor wafer during the production of highly-integrated circuits due to the necessary movements of the semiconductor wafer on a coordinate table (stage). For this reason, current high process speeds aimed at increasing productivity means that either errors in the structure transfer must be accepted or the timing schedule for each exposure step must be expanded to allow the turbulences to die down - both of which result in productivity losses.

A further disadvantage is the difficulty in handling, under cleanroom conditions, of the substrate to be exposed. Using the method of the patent application mentioned above, a wafer must be brought out of the liquid and separated from the liquid after each completed exposure. To begin with, there is a danger that, for example dust or other undesired materials may be present on the surface of the substrates. Further more, the surface of the substrates may need to be cleared of liquid before measurement or inspection can take place. This can only be done at high cost because of the numerous steps, trenches, elevations etc. on said surface. A still further disadvantage is the use of an open-topped container to contain the liquid. The resulting large surface area of liquid provides a path for contaminants to the liquid which can be removed by first passing the liquid through a filter.

#### Object of the Invention

The object of the invention is to provide a highly productive and highly accurate apparatus for photo-lithographic pattern transfer.

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The Essence of the Invention

The invention solves the problem of how to design an apparatus for photolithographic pattern transfer by means of a projection lens, in which a small volume of immersion liquid is used, so that no disruptive turbulences arise and is so configured that possible contaminants lie outside the Depth-Of-Focus of the projection lens and thus cause no patterning errors. Also the substrate handling should be configured to avoid compromising the photo-sensitive layer on the substrates.

According to the invention, the problem is solved by an apparatus for photolithographic structure transfer by means of a projection lens to produce an exposure pattern in a photo-sensitive layer on a substrate, wherein the substrate is movable in steps parallel to the image plane and wherein the substrate is exchangeable, whereby an immersion liquid with a refractive index approximately equal to that of the photo-sensitive layer is disposed in the optical path between the photo-sensitive layer and the projection lens interface facing said layer, the apparatus further comprising two chambers separated from each other and movable with respect to each other, sealed from the atmosphere and filled with immersion liquid, wherein the chambers are disposed in the optical path between the projection lens and the photo-sensitive layer of the substrate, whereby the first chamber, which is rigidly attached to the projection lens, is bounded by the projection lens interface facing the photosensitive layer and by an optically transparent medium, and whereby the second chamber, which is rigidly attached to the substrate, is bounded by the photo-sensitive layer on the substrate and by a further optically transparent medium.

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Glass plates and/or films may be advantageous as optically transparent media.

In order to reduce the volume of moving immersion liquid and thus reduce turbulences in the immersion liquid, it is advantageous when at least one chamber is provided with a device for changing the pressure of the immersion liquid, and when the optically transparent medium of at least one chamber is movable perpendicular to the image plane.

To further increase the resolution of the projection lens as well as to reduce structure transfer errors, immersion liquid may also be disposed between the optically transparent media which bound the chambers.

#### Exemplary embodiments

The drawings depict exemplary embodiments, namely:

Fig. 1 an apparatus according to the invention comprising two glass plates for sealing the chambers,

Fig. 2 an embodiment in which a glass plate is configured to be movable using an annular membrane,

Fig. 3 an embodiment in which the chamber in front of the projection lens is sealed with a film.

The apparatus according to the invention as depicted in Fig. 1 consists of a projection lens 1 rigidly attached to a frame. A chamber 2 is rigidly attached to said projection lens 1, and filled completely with immersion liquid 3. The chamber 2 is sealed from the atmosphere, disposed in the optical path and bounded by projection lens interface 4 facing the photo-sensitive layer 8 and by an optically transparent plane parallel glass plate 5.

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The apparatus further comprises a second chamber 6, attached to the substrate for exposure, for example to a semiconductor wafer. This second chamber 6 is bound by at least the photo-sensitive layer 8, the semiconductor wafer 7 and a further optically transparent plane parallel glass plate 9. Immersion liquid 10 is also present in the second chamber 6. The second chamber 6 including the glass plate 9 and the semiconductor wafer 7 are disposed on the table 11 of a coordinate stage, which comprises actuators 12 configured and arranged to move the semiconductor wafer 7 parallel and perpendicular to the image plane 13.

To increase resolution, immersion liquid 14 is disposed between the glass plates 5 and 9 which form the boundaries of chambers 2 and 6. The surface 15 of the immersion liquid 14 in a container 16 is higher than the glass plate's 5 surface 17 which faces the semiconductor wafer 7. Consequently, the optical path between the projection lens interface 4 and the photo-sensitive layer 8 on the semiconductor wafer 7 only passes through media with approximately the same refractive index as the photo-sensitive layer 8, assuming that the refractive indexes of the immersion liquids 3, 10 and 14 approximately match. The moving volume of immersion liquid 14, and thus the amount of turbulences in this liquid 14, may be reduced by minimizing, in the design, the distance between the two mutually movable chambers 1 and 6.

As depicted in figure 2, it may be advantageous to modify the chamber 2 such that a glass plate 18 is movable perpendicular to the image plane 13 by means of an annular membrane 19. The film 20 in figure 3 fulfills a similar purpose. In these cases, the chamber 2 is provided with a connection 21 to an apparatus 22 for changing the pressure of the immersion liquid 3.

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During exposure of the photo-sensitive layer 8, the glass plate 18 is moved in the direction of the image plane 13 by an increased pressure in the chamber 2. During the movement of the table 11, damage to the glass plate 18 or film 20 is avoided by reducing the pressure of the immersion liquid 3 in the chamber 2 - this moves the glass plate 18 or film 20 away from the moving glass plate 9.

The apparatus from the embodiment may also be employed without immersion liquid 14. In this case, there will be no turbulence problems. The apparatus retains the advantages of the invention, because the afstand between chambers 2 and 6 can be kept to a minimum, and the surfaces sensitive to contamination (including dust) lie outside the Depth-Of-Focus of the projection lens 1.

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Claims

## 1. Apparatus for photo-lithographic structure transfer by means of:

a projection lens 1 to produce an exposure pattern in a photo-sensitive layer 8 on a substrate 7, wherein the substrate 7 is movable in steps parallel to the image plane 13 and wherein the substrate 7 is exchangeable, whereby an immersion liquid 3,10,14 with a refractive index approximately equal to that of the photo-sensitive layer 8 is disposed in the optical path between the photo-sensitive layer 8 and the projection lens interface 4 facing said layer 8, characterized in that:

the apparatus further comprises two chambers 2,6, separated from each other and movable with respect to each other, sealed from the atmosphere and filled with immersion liquid 3,10, wherein the chambers 2,6 are disposed in the optical path between the projection lens 1 and the photo-sensitive layer 8 of the substrate 7;

whereby the first chamber 3, which is rigidly attached to the projection lens 1, is bounded by the projection lens interface 4 facing the photosensitive layer 8 and by an optically transparent medium 5; and

whereby the second chamber 6, which is rigidly attached to the substrate 7, is bounded by the photo-sensitive layer 8 on the substrate 7 and by a further optically transparent medium 9.

2. Apparatus according to claim 1, characterised in that the optically transparent media 5,9 are glass plates and/or films 20.
3. Apparatus according to claims 1 and 2, characterised in that at least one chamber 2,6 is provided with a device for changing the pressure of the immersion liquid, and in that the optically transparent medium 5,10,20 of at least one chamber 2,6 is movable perpendicular to the image plane 13.
4. Apparatus according to claims 1 to 3, characterised in that immersion liquid 14 is also disposed between the optically transparent media 5,9,20 which bound the chambers 2,6.

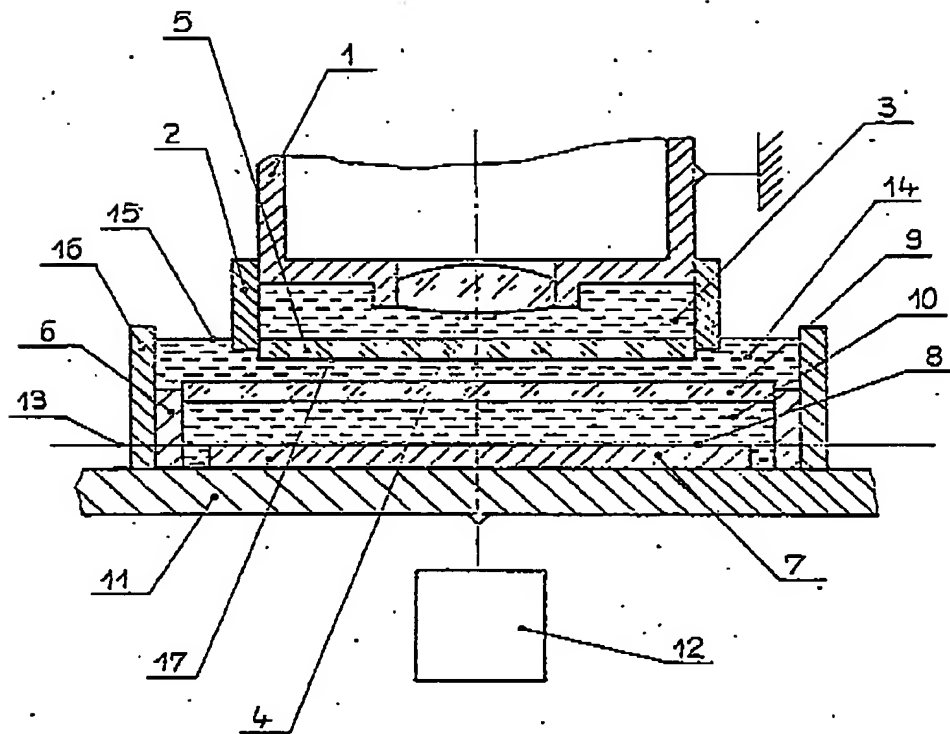
Attached are 3 pages of drawings.

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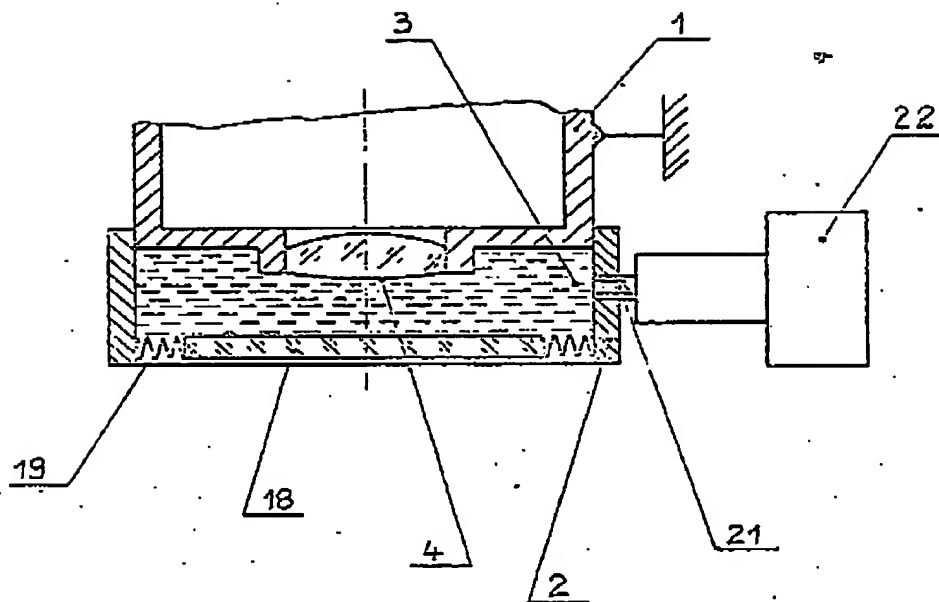


Figur 1

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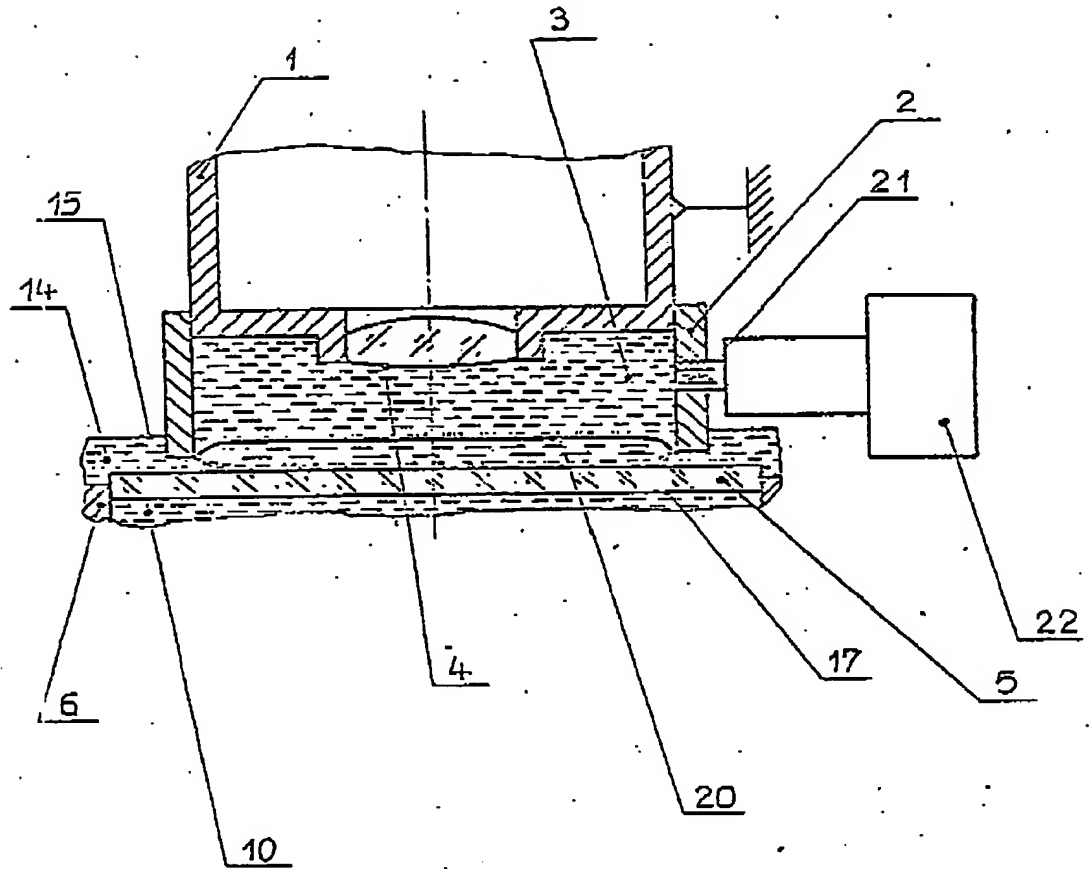


Figur 2

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Figur 3

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